Radiometric Comparison of Ikonos & Landsat 7 ETM+ Observations: Implications for Science Applications

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High Spatial Resolution Commercial Imagery Workshop
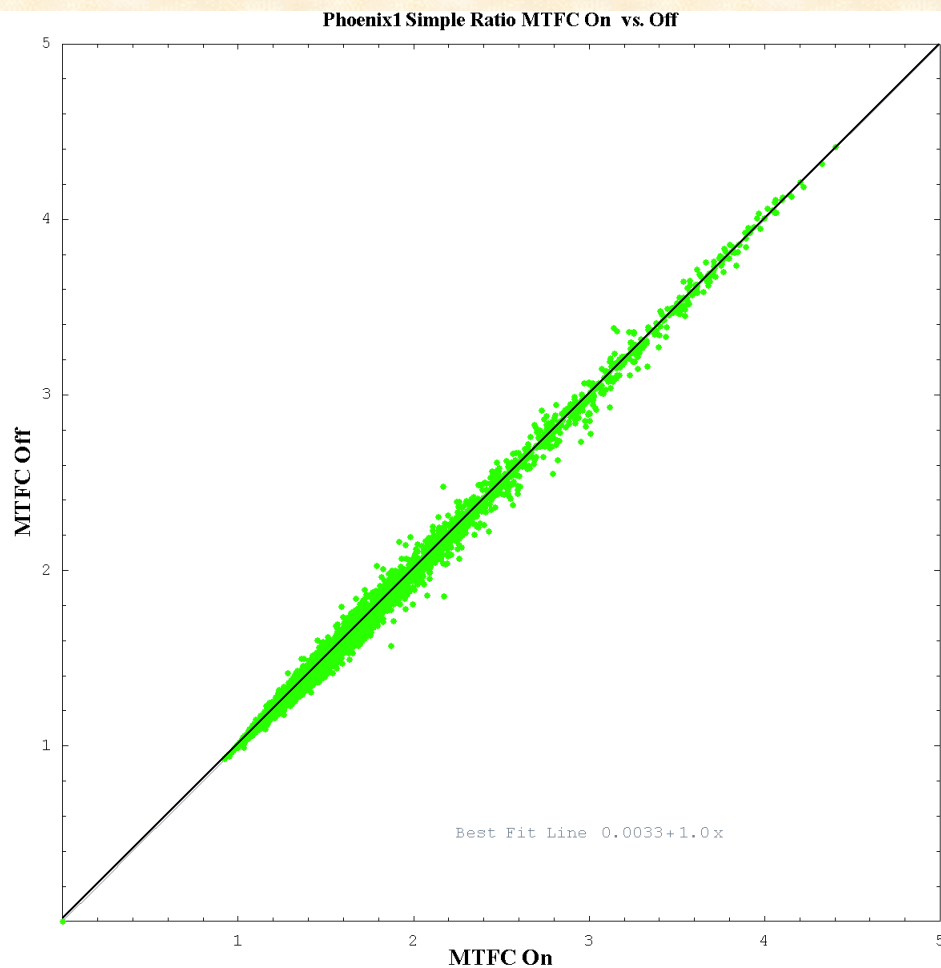**March 19-21, 2001; Greenbelt, Maryland**

Research Goals:

• **Virtual Ground Truth Capability of Ikonos**

• **Radiometric Comparison with Established Sensors**
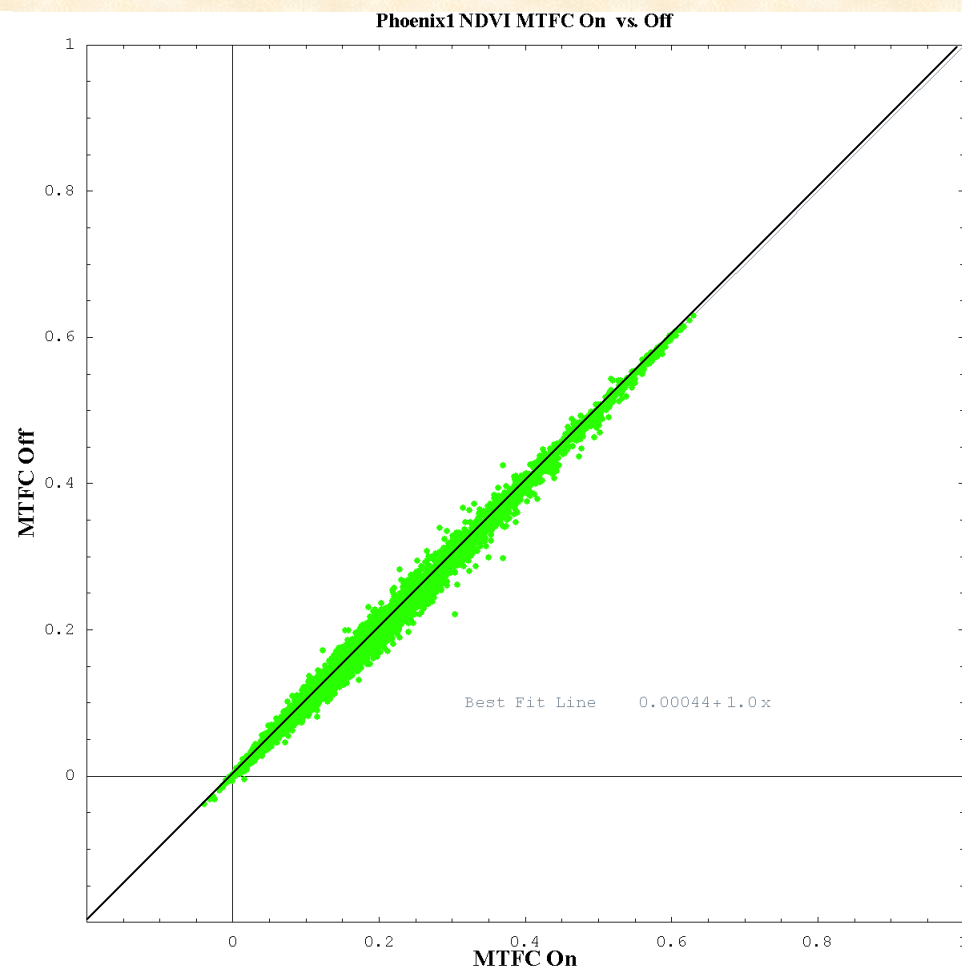
• **Value to Scientific Investigations**

Konza Prairie   Ikonos 4m (NIR, Red, Green)

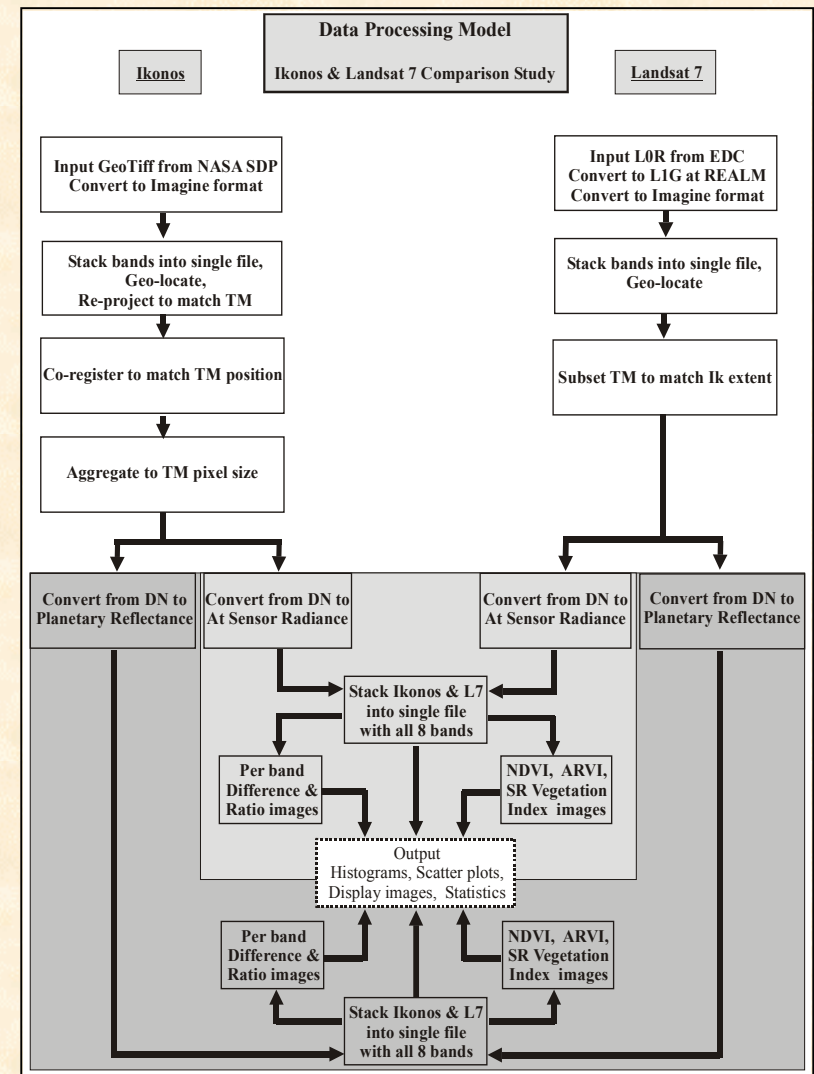# Comparison of Ikonos MTFC On and Off: Planetary Reflectance

Simple Ratio

NDVI

Phoenix1 Simple Ratio MTFC On vs. Off

MTFC Off

MTFC On

Best Fit Line 0.0033+1.0x

Phoenix1 NDVI MTFC On vs. Off

MTFC Off

MTFC On

Best Fit Line 0.00044+1.0x

Methodology for Comparison of Ikonos and Landsat 7:

- **Acquire Ikonos from Science Data Purchase**

- **Acquire coincident ETM+**

- **Match Ikonos to Landsat**

- **Band-to-Band Radiometric Comparison**

- **Vegetation Index Comparison**

Data Processing Model

Ikonos & Landsat 7 Comparison Study

Ikonos | Landsat 7

Input GeoTiff from NASA SDP
Convert to Imagine format

Input L0R from EDC
Convert to L1G at REALM
Convert to Imagine format

Stack bands into single file,
Geo-locate,
Re-project to match TM

Stack bands into single file,
Geo-locate

Co-register to match TM position

Subset TM to match Ik extent

Aggregate to TM pixel size

Convert from DN to Planetary Reflectance | Convert from DN to At Sensor Radiance | Convert from DN to At Sensor Radiance | Convert from DN to Planetary Reflectance

Stack Ikonos & L7 into single file with all 8 bands

Per band Difference & Ratio images

NDVI, ARVI, SR Vegetation Index images

Output
Histograms, Scatter plots,
Display images, Statistics

Per band Difference & Ratio images

NDVI, ARVI, SR Vegetation Index images

Stack Ikonos & L7 into single file with all 8 bands

Acquisitions for Comparison of Ikonos and Landsat 7

	Beltsville, MD	Konza, KS	Sevilleta, NM	Tahoe, CA
Land Cover	Humid Forest	Grassland	Semi-Arid	Water, Snow
Vegetation				
Greening	May 2000	May 2000	May 2000	
Full Leaf	July 2000	July 2000	July 2000	
Senescence	Sept 2000	Sept 2000	Sept 2000	
Snow				March 2000

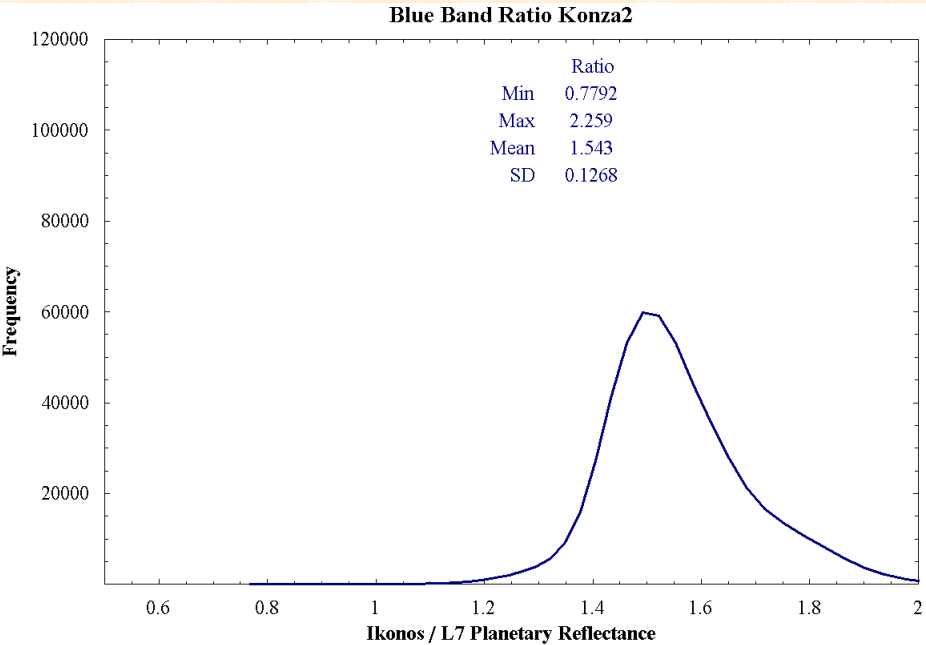|	Phoenix, AZ	Tahoe, CA	Mongu, Za	Beltsville, MD	Konza, KS	Sevilleta, NM
Land Cover	Urban	Water, Snow	Miombo	Humid Forest	Grassland	Semi-Arid
Vegetation						
Greening	-	-	-	June 2000	May 2000	May 2000
Full Leaf	-	-	April 2000	-	July 2000	July 2000
Senescence	Oct 1999	-	-	Sept 2000	Sept 2000	Sept 2000
Snow	-	(4/ 2000) 2/2001	-	-	-	-

Acquisitions for Comparison of Ikonos and Landsat 7

Task	Location	Target date	Acquisition date	Delivery date	Months to Deliver
630	Tahoe City, CA, 1	3/12/00	4/05/00	6/09/00	2
746	Beltsville, MD, 1	5/11/00	6/03/00	7/26/00	2
746	Beltsville, MD, 2	7/30/00	9/10/00	2/28/01	5
746	Beltsville, MD, 3	10/2/00	9/30/00	10/25/00	1
747	Konza Prairie LTER, KS, 1	4/28/00	5/11/00	7/07/00	2
747	Konza Prairie LTER, KS, 2	7/28/00	7/16/00	7/26/00	0.25
747	Konza Prairie LTER, KS, 3	9/28/00	9/15/00	10/16/00	1
680	Sevilleta LTER, NM, 1	5/14/00	5/12/00	12/20/00	7
748	Sevilleta LTER, NM, 2	7/28/00	7/23/00	8/10/00	0.75
748	Sevilleta LTER, NM, 3	9/28/00	9/18/00	10/20/00	1
748	Sevilleta LTER, NM, 4	10/12/00	10/02/00	11/08/00	1
n.a.	Sevilleta LTER, NM, 5	n.a.	12/03/00	on order	n.a.
456	Mongu, Zambia	n.a.	4/10/00	10/20/00	n.a.
923	Tahoe City, CA, 2	2/11/00	unknown	on order	n.a.
n.a.	Phoenix, AZ, Off	n.a.	10/12/99	6/08/00	n.a.
n.a.	Phoenix, AZ, On	n.a.	10/12/99	6/08/00	n.a.

Total	KEY			
2	ON	: collected within 3 days of target		
5	NEAR	: collected within 2 weeks of target		
2	OFF	: collected within one month of target		
1	FAR OFF	: collected over a month after target		
0	FAILED	: unsuccessful or otherwise not acquired		
5	Other			
16	"On" and "Near" are within the 2-week tasking parameters.			

TM 30m & Ikonos 4m

Konza Prairie LTER & EOS Core Site, July16, 2000 (4,3,2)
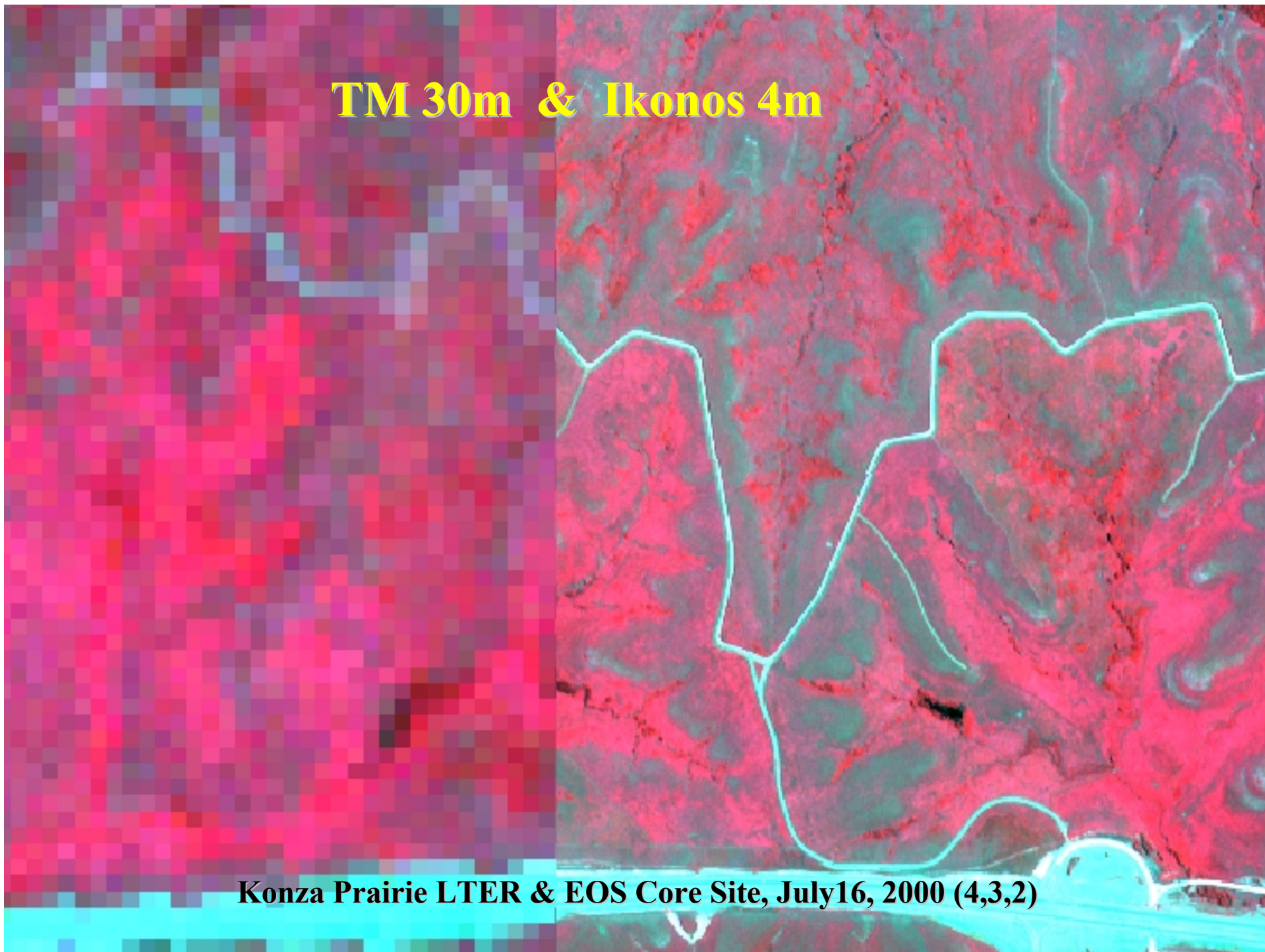
TM 30m & Ikonos Aggregated to 30m
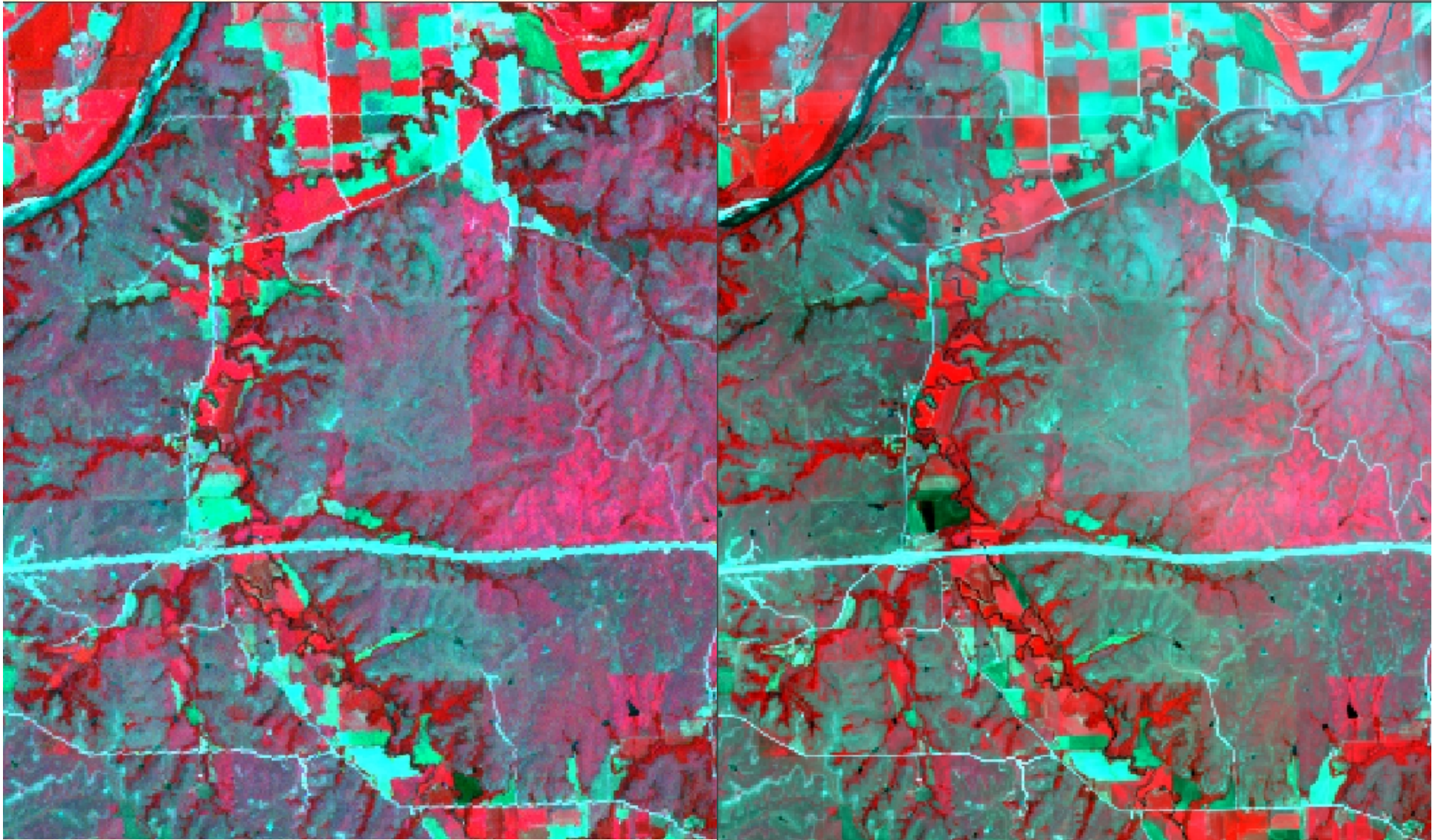
Konza Prairie LTER & EOS Core Site, July16, 2000 (4,3,2)

Comparison of Ikonos and Landsat 7

Blue Band Konza2

	Ikonos	LS7
Min	66.93	43.44
Max	149.5	121.0
Mean	82.49	54.83
SD	7.371	5.743

Blue Band Radiance, Konza2

Best Fit Line   16.0 + 0.470 x

Comparison of Ikonos and Landsat 7

Blue Band Planetary Reflectance, Konza2

Best Fit Line   0.0294 + 0.461 x

Landsat7

Ikonos

Blue Band Konza2

	Ikonos	LS7
Min	0.1259	0.08121
Max	0.2803	0.2223
Mean	0.1547	0.1007
SD	0.01382	0.01055

Frequency

Planetary Reflectance

Comparison of Ikonos and Landsat 7

Blue Band Difference Konza2

	Difference
Min	−0.04551
Max	0.1325
Mean	0.05398
SD	0.01125

Ikonos − L7 Planetary Reflectance

Blue Band Ratio Konza2

	Ratio
Min	0.7792
Max	2.259
Mean	1.543
SD	0.1268

Ikonos / L7 Planetary Reflectance

Comparison of Ikonos and Landsat 7

Green Band Konza2

	Ikonos	LS7
Min	0.1101	0.06241
Max	0.3261	0.2264
Mean	0.1627	0.09348
SD	0.01792	0.01343

Green Band Planetary Reflectance, Konza2

Best Fit Line   0.0110 + 0.507 x

Comparison of Ikonos and Landsat 7

Red Band Konza2

	Ikonos	LS7
Min	0.09278	0.03591
Max	0.4297	0.2463
Mean	0.1715	0.07093
SD	0.02968	0.02170

Red Band Planetary Reflectance, Konza2

Best Fit Line $-0.0232 + 0.549\,x$

Comparison of Ikonos and Landsat 7

NIR Band Konza2

	Ikonos	LS7
Min	0.1334	0.07246
Max	0.7771	0.5929
Mean	0.4936	0.3187
SD	0.06942	0.05581

NIR Band Planetary Reflectance, Konza2

Best Fit Line   −0.00951 + 0.665 x

Comparison of Ikonos and Landsat 7

Simple Ratio DN Values, Konza2

Landsat7 vs Ikonos

Best Fit Line $-0.0375 + 0.785\,x$
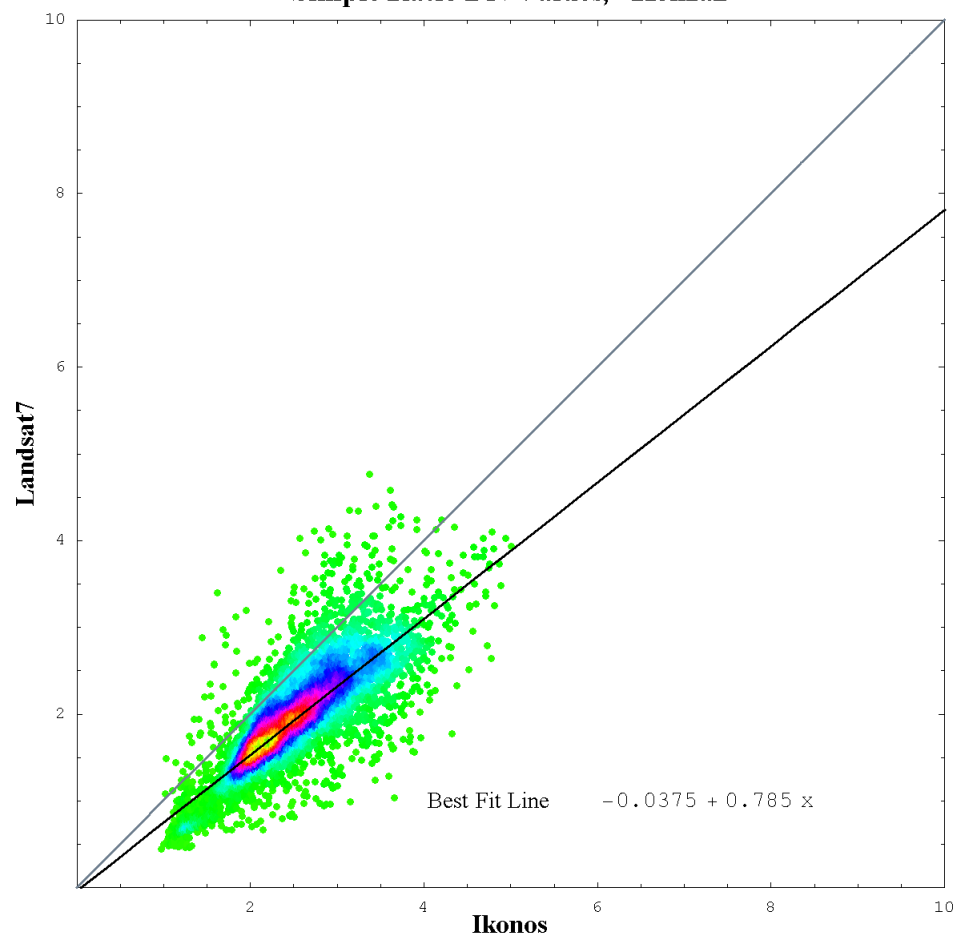
Simple Ratio Planetary Reflectance, Konza2

Landsat7 vs Ikonos

Best Fit Line $-0.668 + 1.87\,x$

Comparison of Ikonos and Landsat 7

NDVI DN Values, Konza2

Landsat7

Best Fit Line $-0.224 + 1.24 \, x$

Ikonos

NDVI Planetary Reflectance, Konza2

Landsat7

Best Fit Line $0.124 + 1.05 \, x$
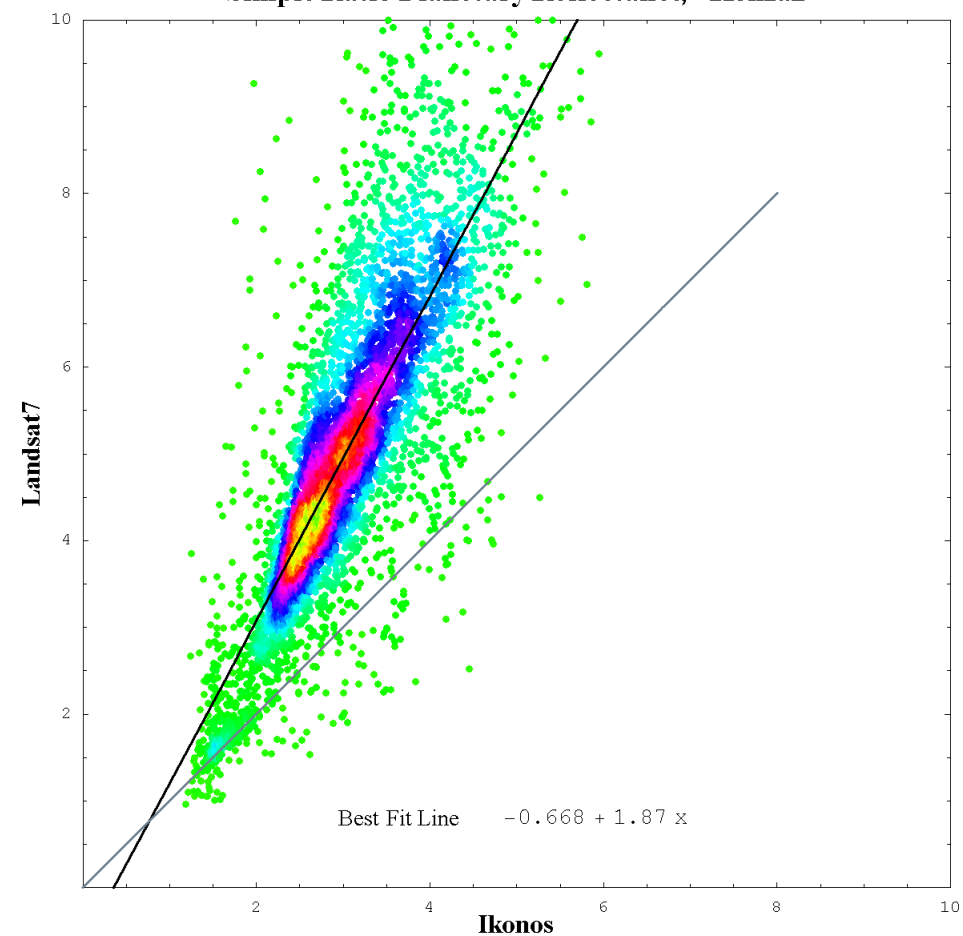
Ikonos

Comparison of Ikonos and Landsat 7

ARVI DN Values, Konza2

Landsat7 vs Ikonos

Best Fit Line   −0.206 + 1.44 x

ARVI Planetary Reflectance, Konza2

Landsat7 vs Ikonos

Best Fit Line   0.275 + 1.11 x
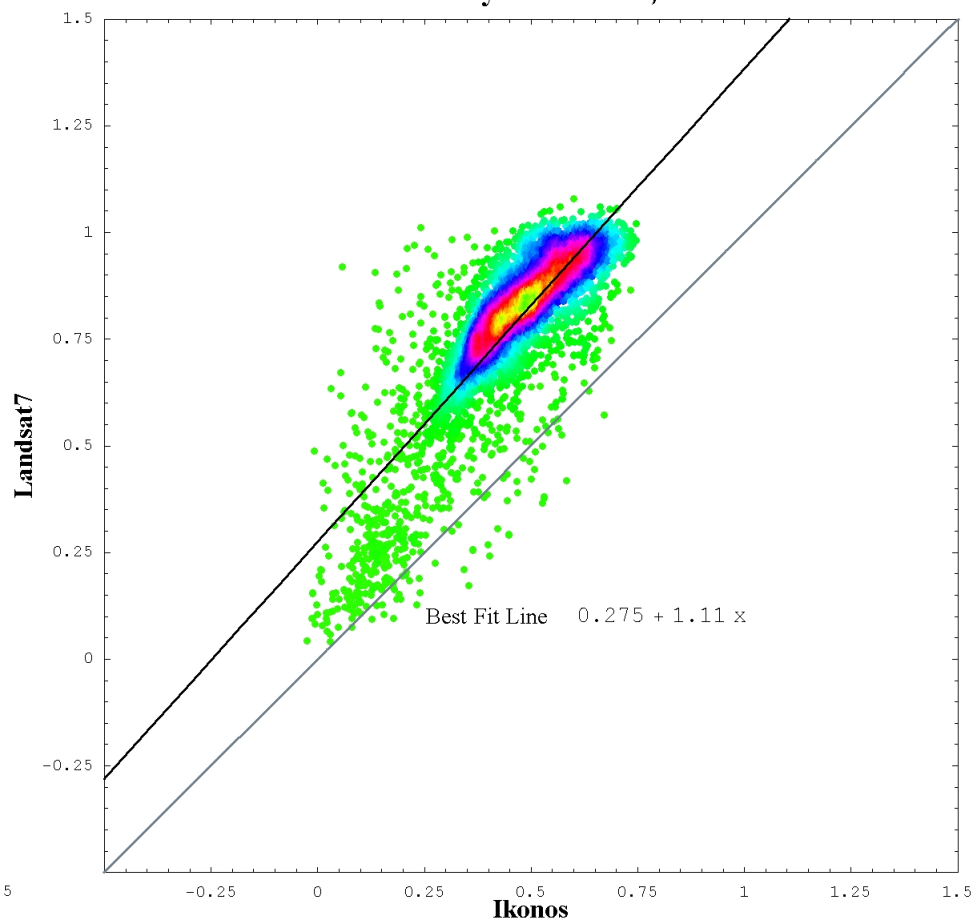
Comparison of Ikonos and Landsat 7

Ikonos Red vs. NIR Band Planetary Reflectance, Konza2
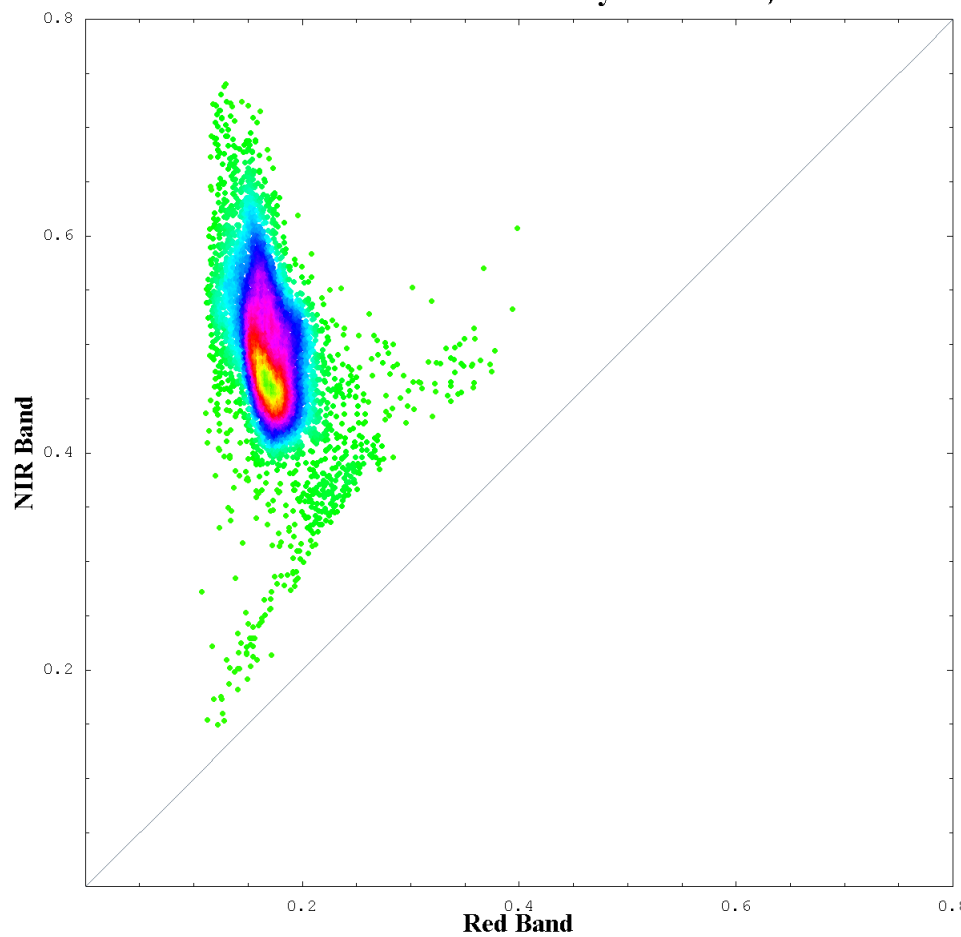
Landsat 7 Red vs. NIR Band Planetary Reflectance, Konza2
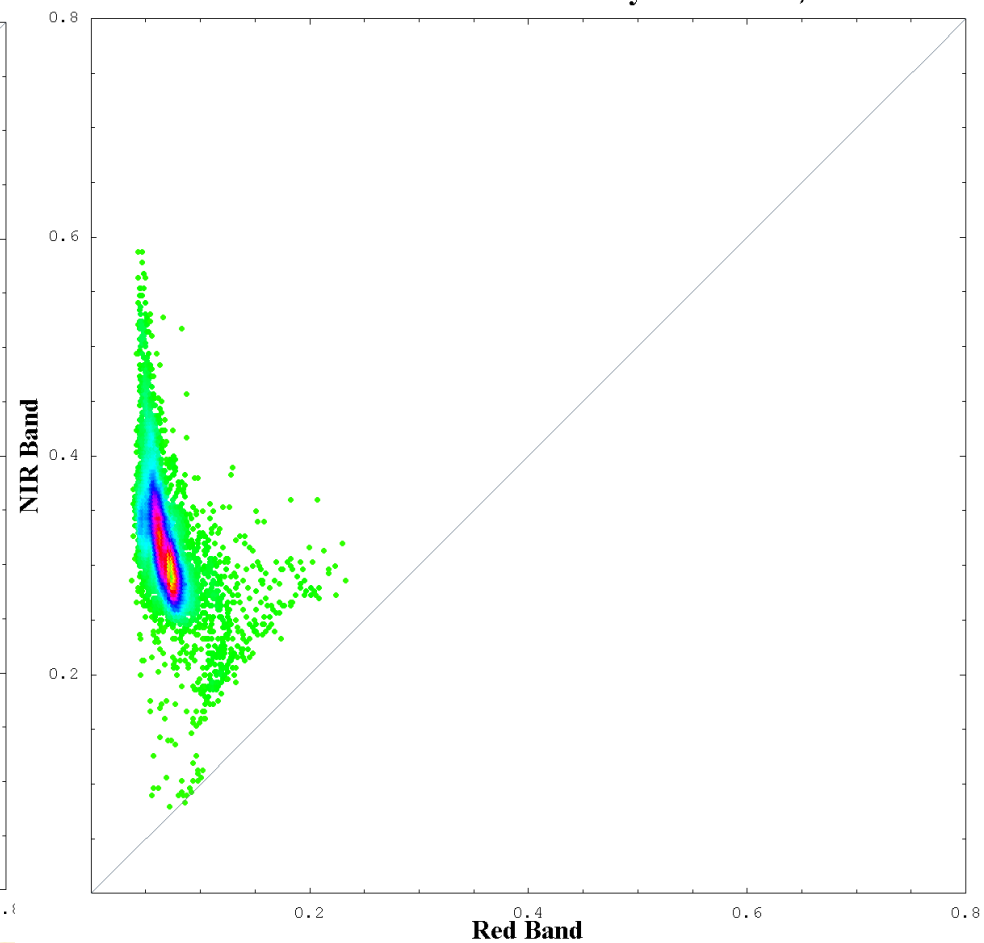
Comparison of Ikonos and Landsat 7: Blue Bands

Phoenix MTFC On 10/12/99

Blue Band Planetary Reflectance,   Phoenix1_On

Best Fit Line   0.0328 + 0.838 x

Phoenix MTFC Off 10/12/99

Blue Band Planetary Reflectance,   Phoenix1_Off

Best Fit Line   0.0333 + 0.835 x
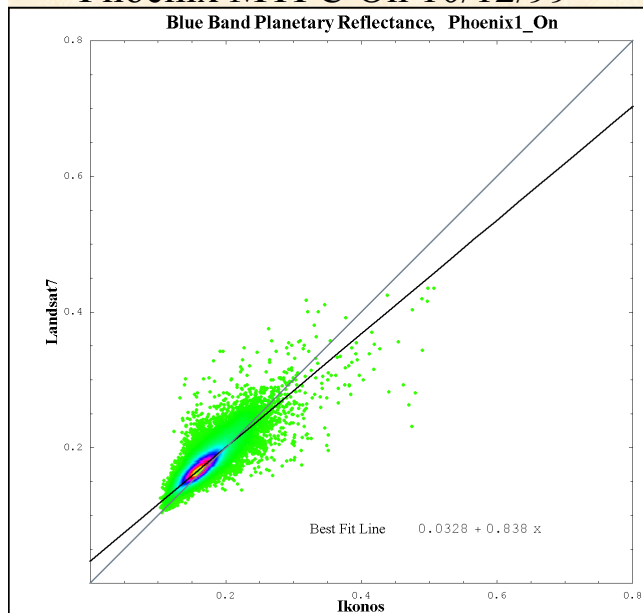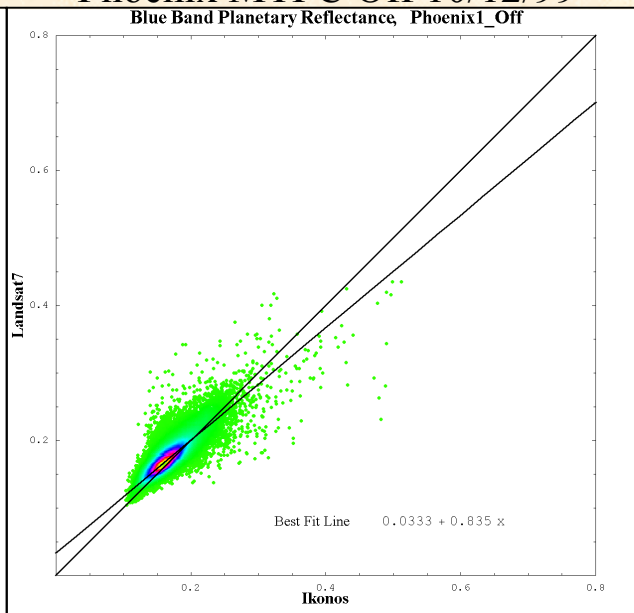
Mongu, Zambia 4/10/00

Blue Band Planetary Reflectance,   Mongu1
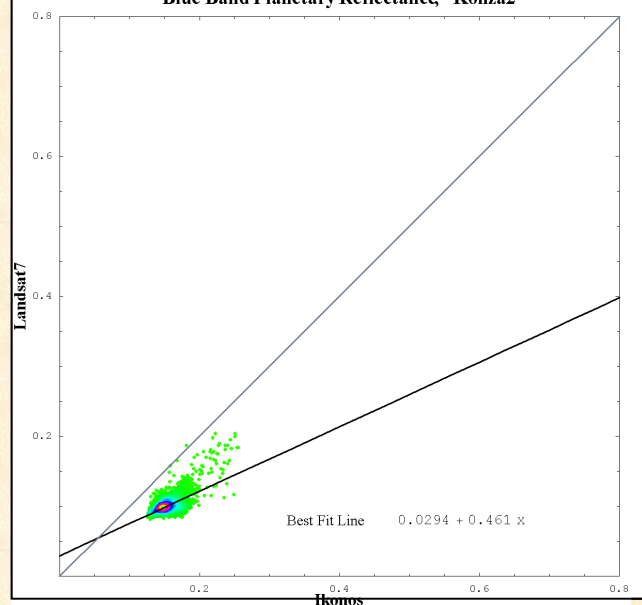
Best Fit Line   −0.00132 + 0.823 x

Blue Band Planetary Reflectance,   Konza2

Best Fit Line   0.0294 + 0.461 x

Blue Band Planetary Reflectance,   Sevilleta4

Best Fit Line   0.0256 + 0.851 x

Konza Prairie, KS 7/28/00
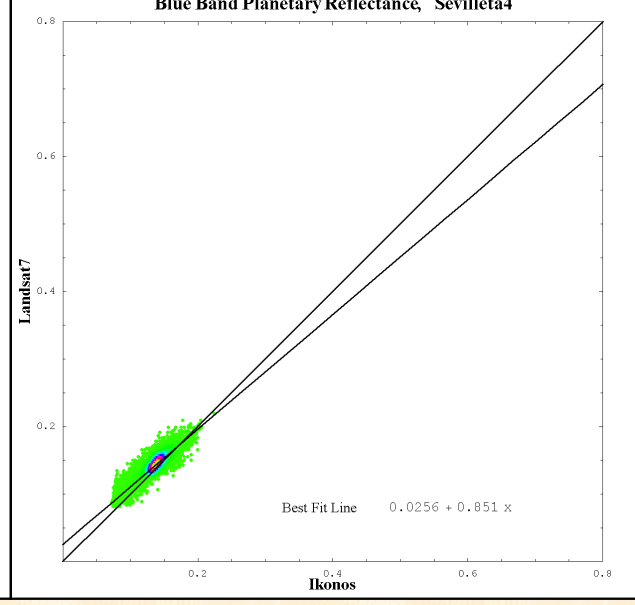
Sevilleta, NM 10/2/00

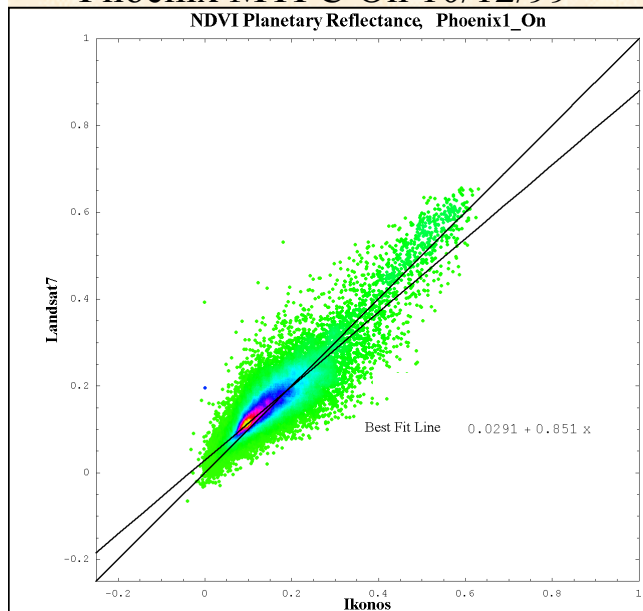# Comparison of Ikonos and Landsat 7: Green Bands

Phoenix MTFC On 10/12/99

Green Band Planetary Reflectance, Phoenix1_On

Best Fit Line   0.0396 + 0.680 x
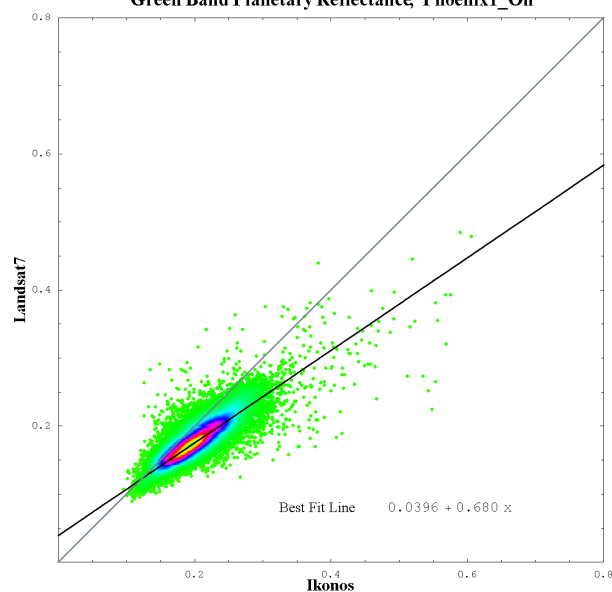
Phoenix MTFC Off 10/12/99

Green Band Planetary Reflectance, Phoenix1_Off

Best Fit Line   0.0401 + 0.677 x
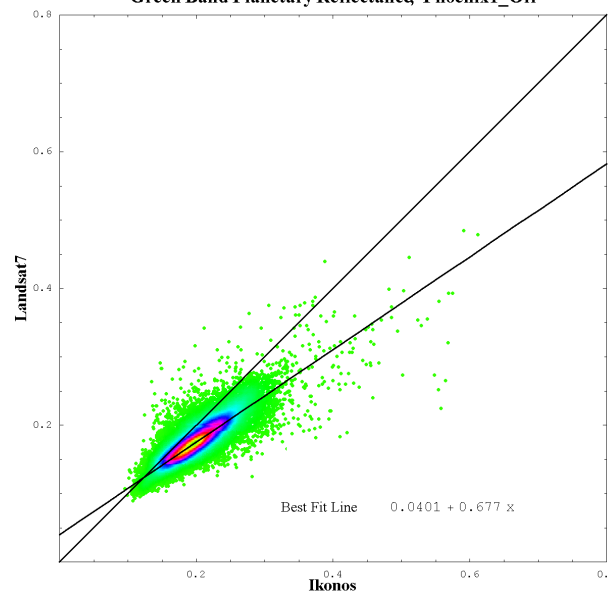
Mongu, Zambia 4/10/00

Green Band Planetary Reflectance, Mongu1
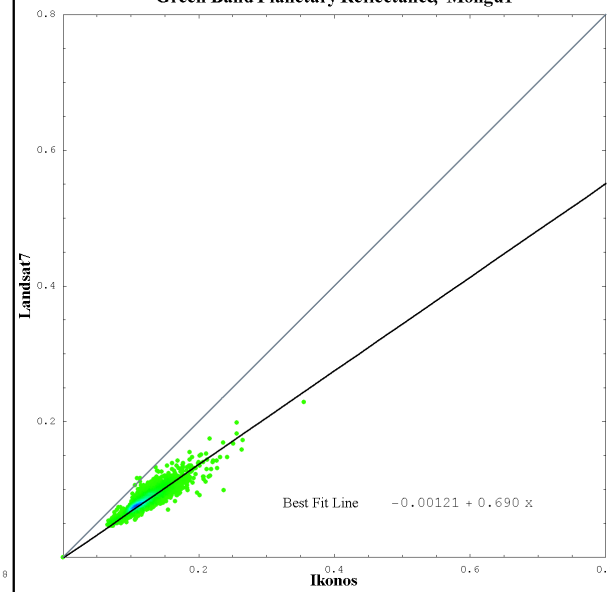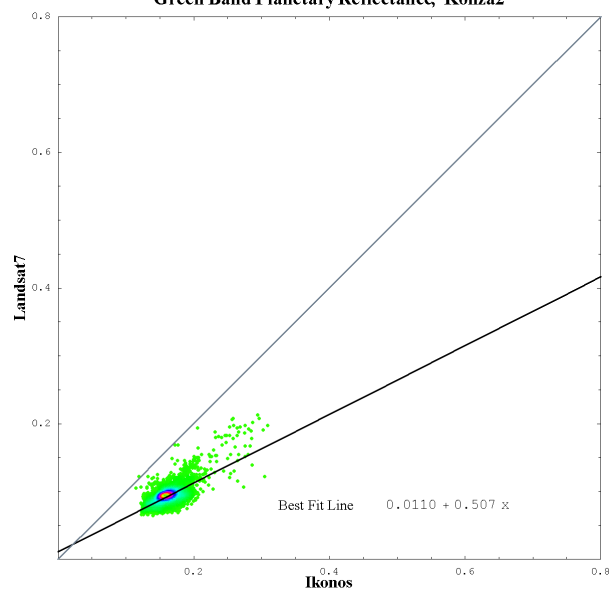
Best Fit Line   −0.00121 + 0.690 x

Green Band Planetary Reflectance, Konza2

Best Fit Line   0.0110 + 0.507 x

Green Band Planetary Reflectance, Sevilleta4

Best Fit Line   0.0232 + 0.758 x

Konza Prairie, KS 7/28/00
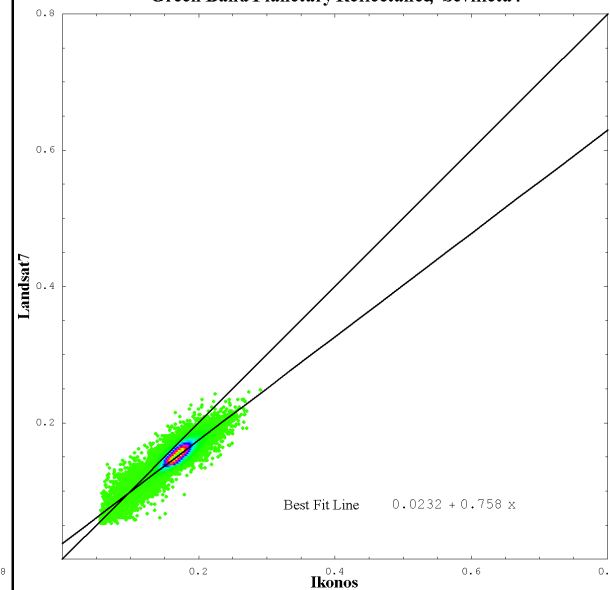
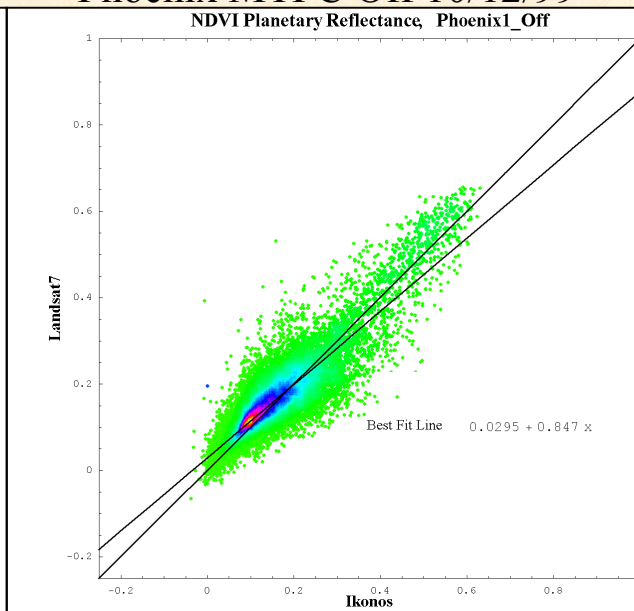Sevilleta, NM 10/2/00

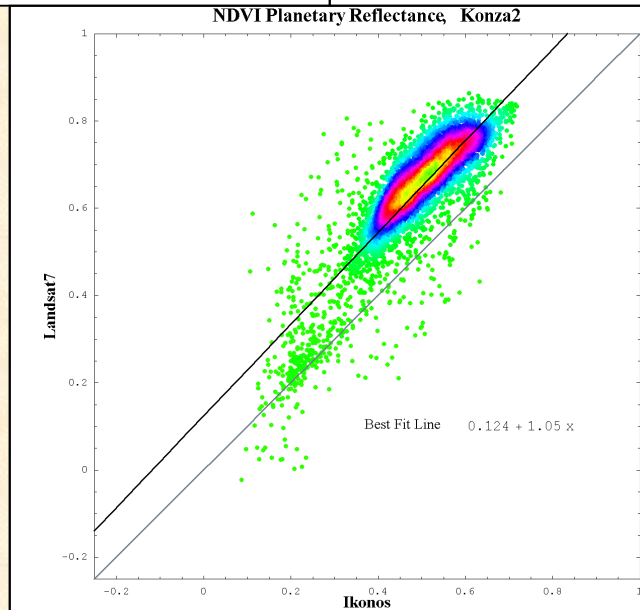# Comparison of Ikonos and Landsat 7: Red Bands

Phoenix MTFC On 10/12/99   Phoenix MTFC Off 10/12/99   Mongu, Zambia 4/10/00
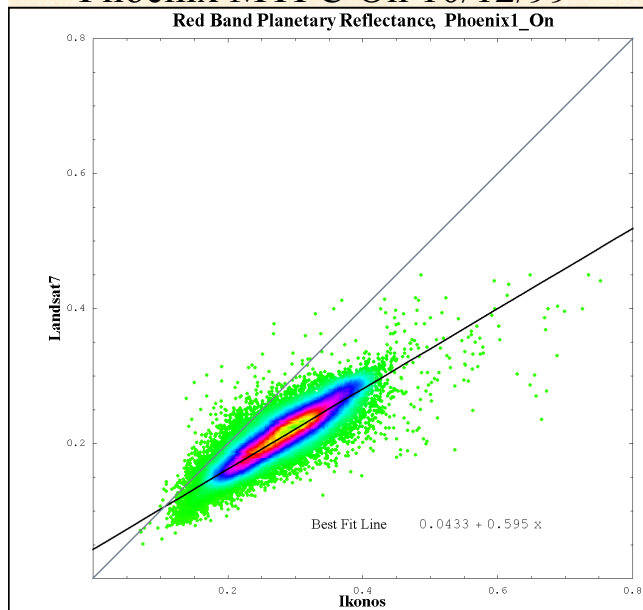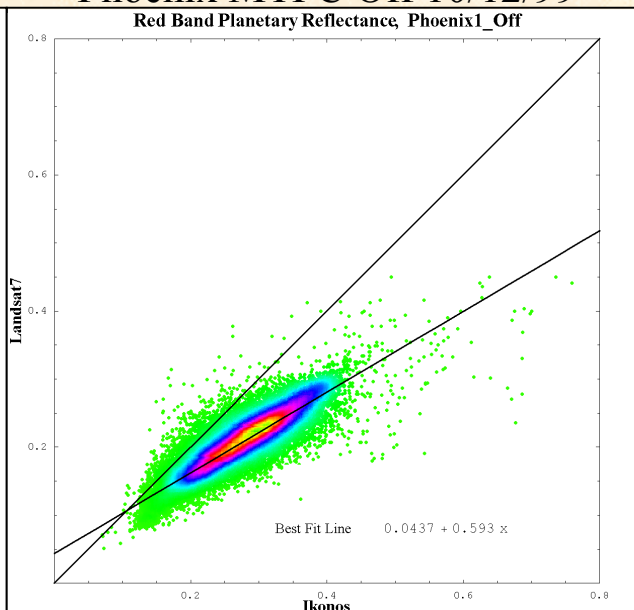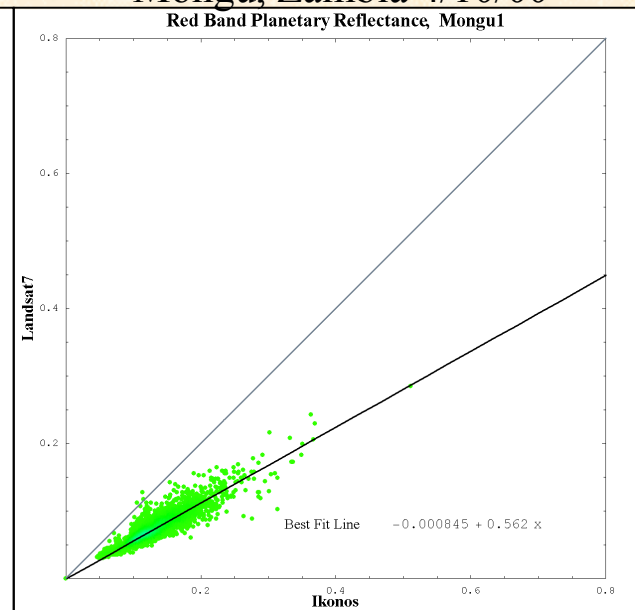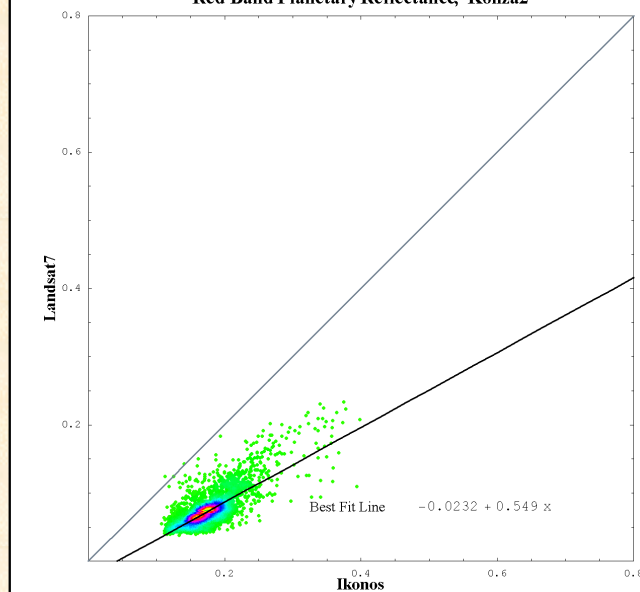
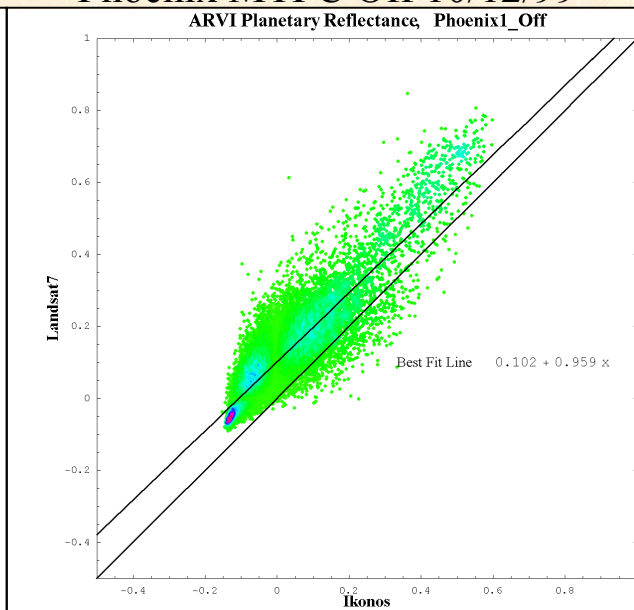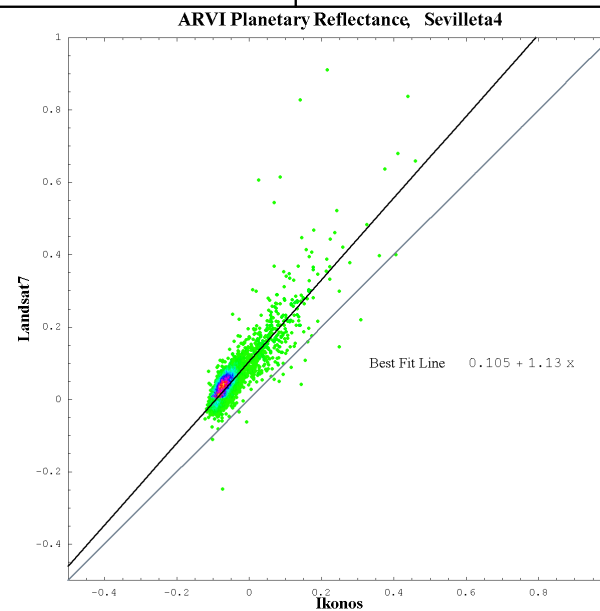Konza Prairie, KS 7/28/00   Sevilleta, NM 10/2/00
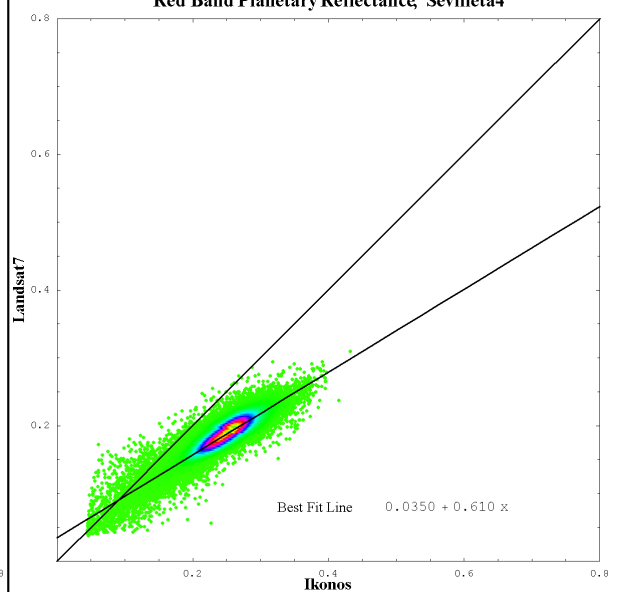
Comparison of Ikonos and Landsat 7: NIR Bands

Phoenix MTFC On 10/12/99

NIR Band Planetary Reflectance, Phoenix1_On

Best Fit Line   0.0594 + 0.599 x

Phoenix MTFC Off 10/12/99

NIR Band Planetary Reflectance, Phoenix1_Off

Best Fit Line   0.0603 + 0.597 x
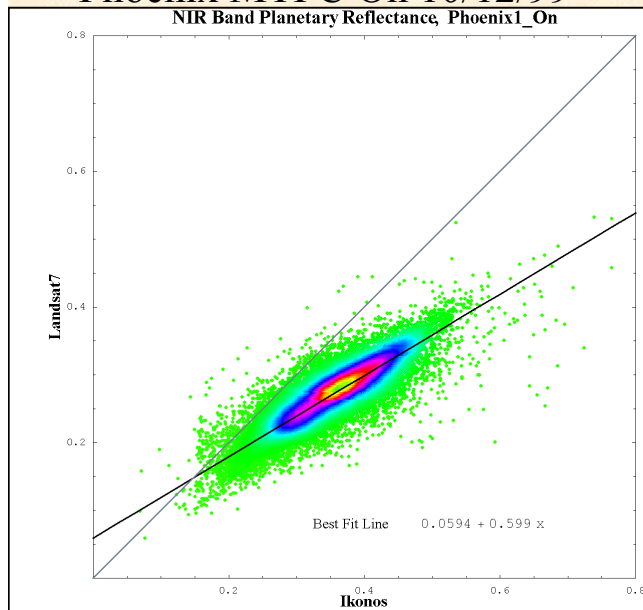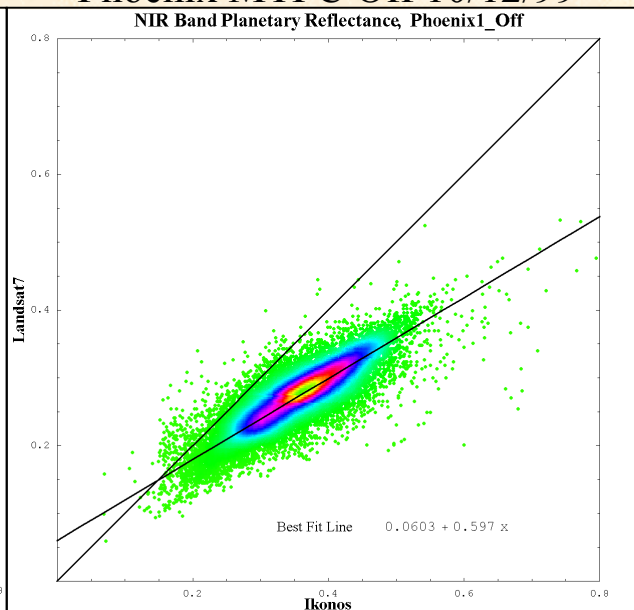
Mongu, Zambia 4/10/00

NIR Band Planetary Reflectance, Mongu1

Best Fit Line   -0.00187 + 0.631 x

NIR Band Planetary Reflectance, Konza2

Best Fit Line   -0.00951 + 0.665 x

NIR Band Planetary Reflectance, Sevilleta4

Best Fit Line   0.0512 + 0.610 x

Konza Prairie, KS 7/28/00   Sevilleta, NM 10/2/00
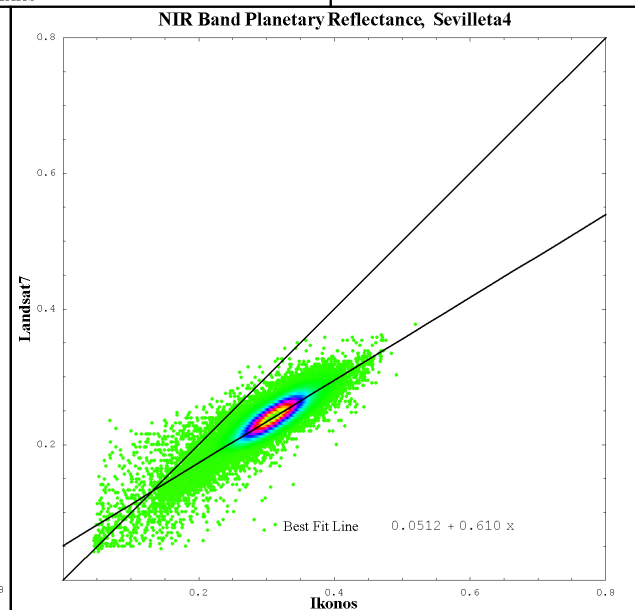
Comparison of Ikonos and Landsat 7: Simple Ratio Vegetation Index

Phoenix MTFC On 10/12/99
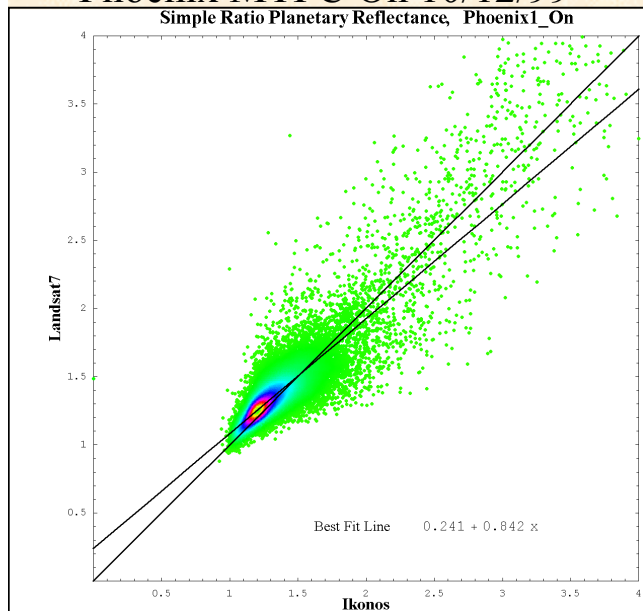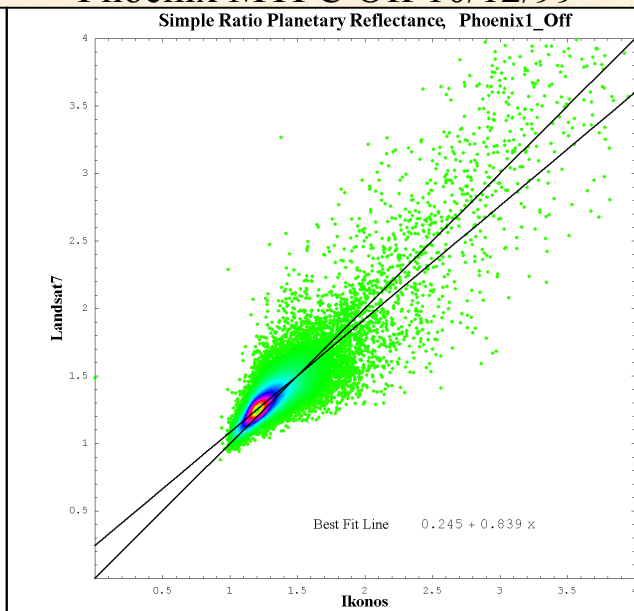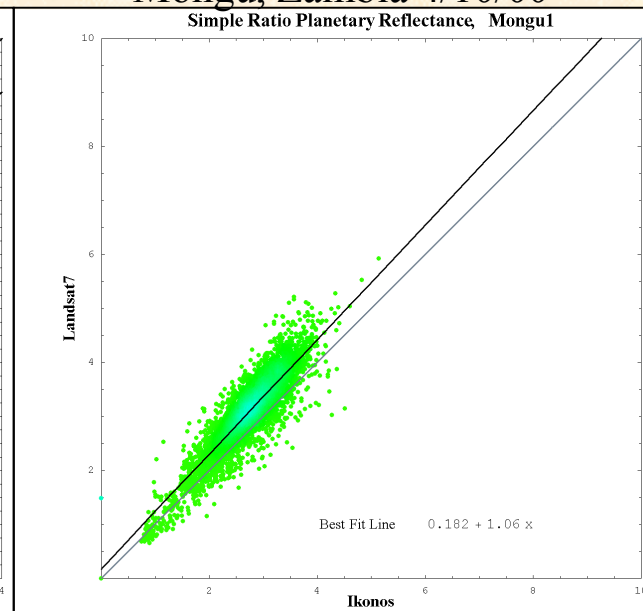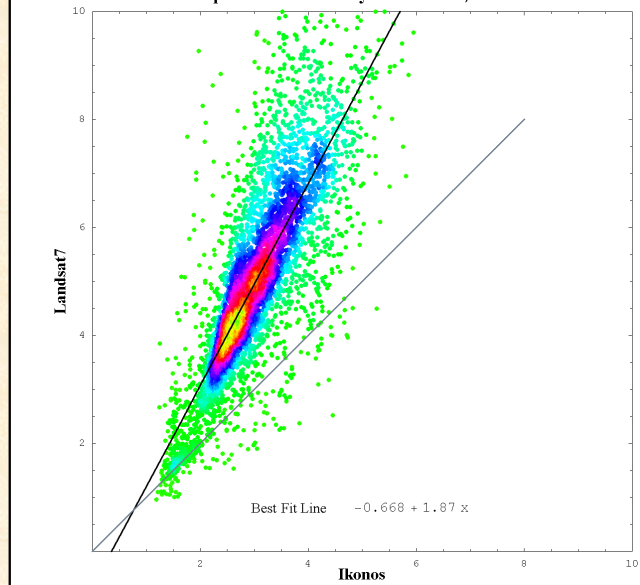
Phoenix MTFC Off 10/12/99

Mongu, Zambia 4/10/00

Konza Prairie, KS 7/28/00
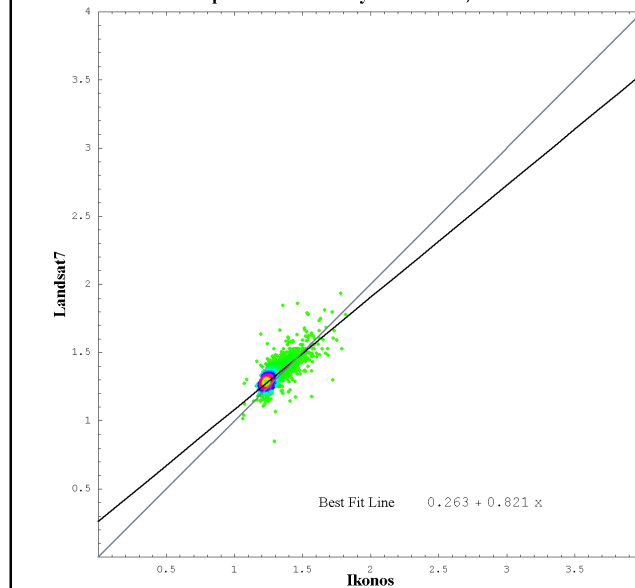
Sevilleta, NM 10/2/00

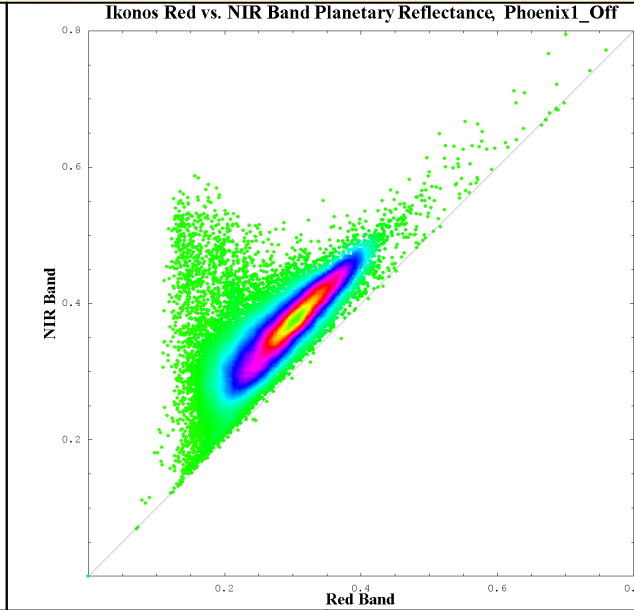# Comparison of Ikonos and Landsat 7: NDVI

Phoenix MTFC On 10/12/99
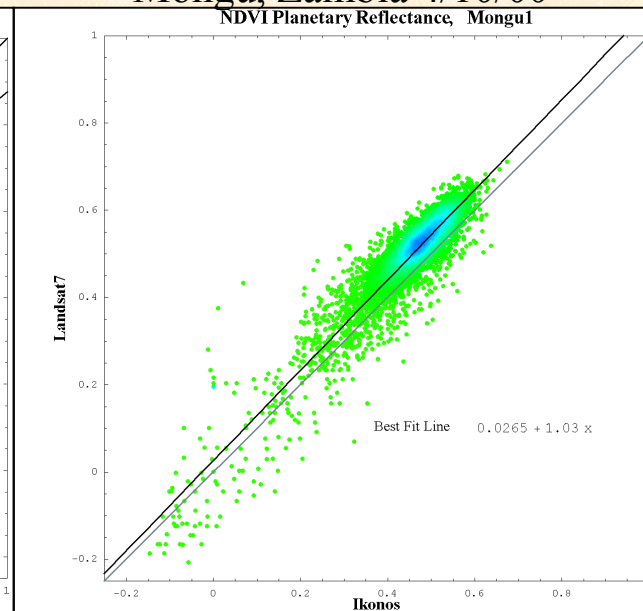
Phoenix MTFC Off 10/12/99

Mongu, Zambia 4/10/00

Konza Prairie, KS 7/28/00
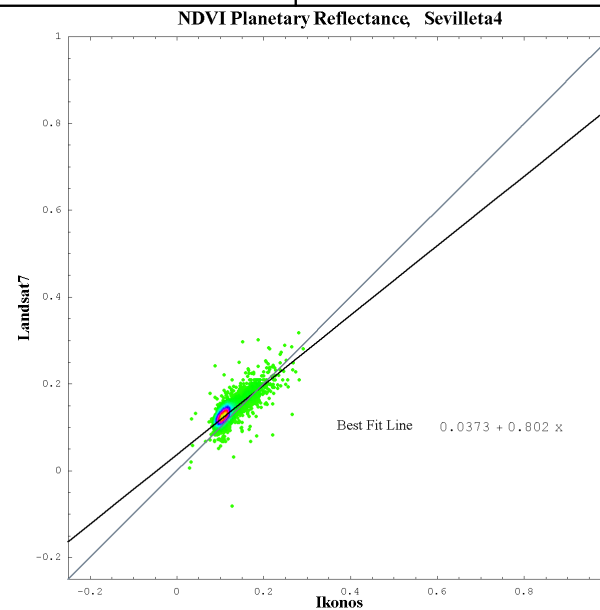
Sevilleta, NM 10/2/00

Comparison of Ikonos and Landsat 7: ARVI

Phoenix MTFC On 10/12/99   Phoenix MTFC Off 10/12/99   Mongu, Zambia 4/10/00
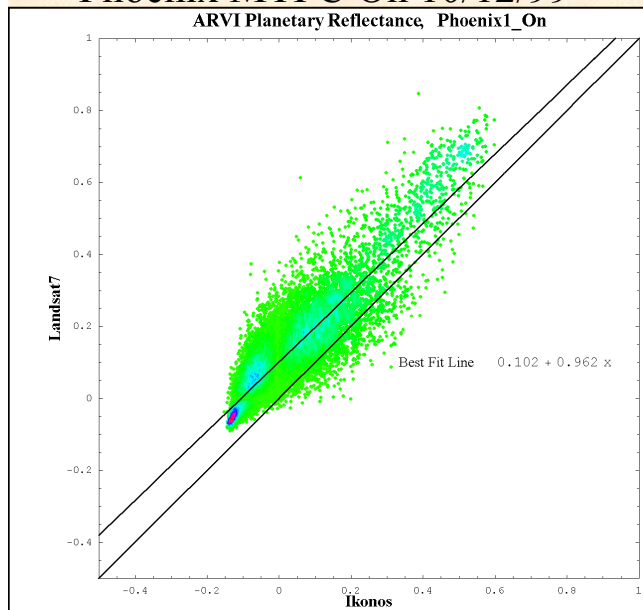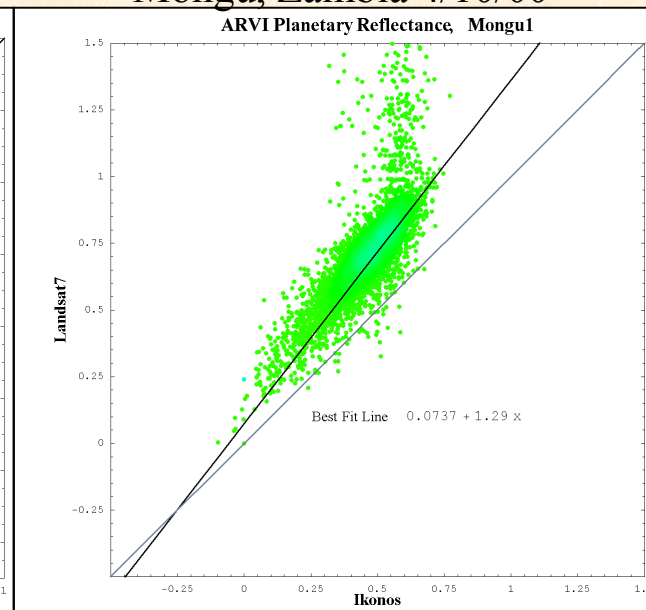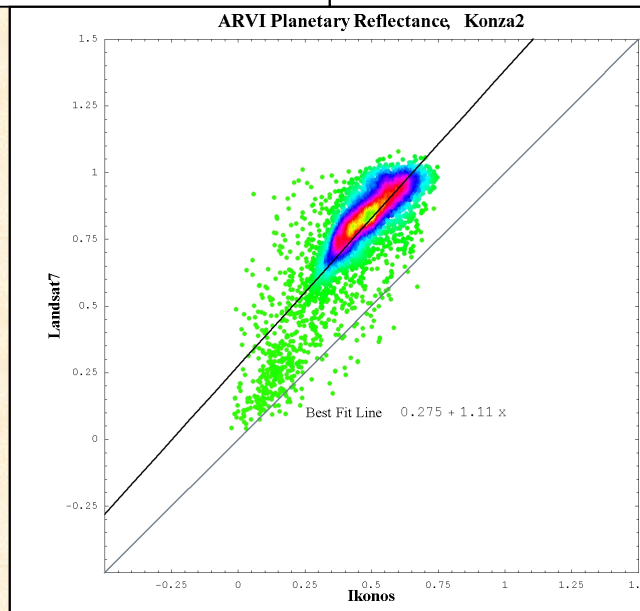
Konza Prairie, KS 7/28/00   Sevilleta, NM 10/2/00

Comparison of Ikonos and Landsat 7: Ikonos NIR vs Red Bands

Phoenix MTFC On 10/12/99
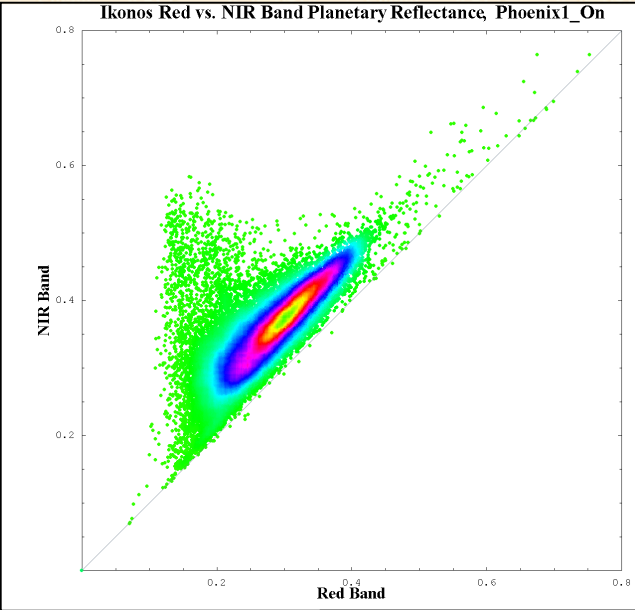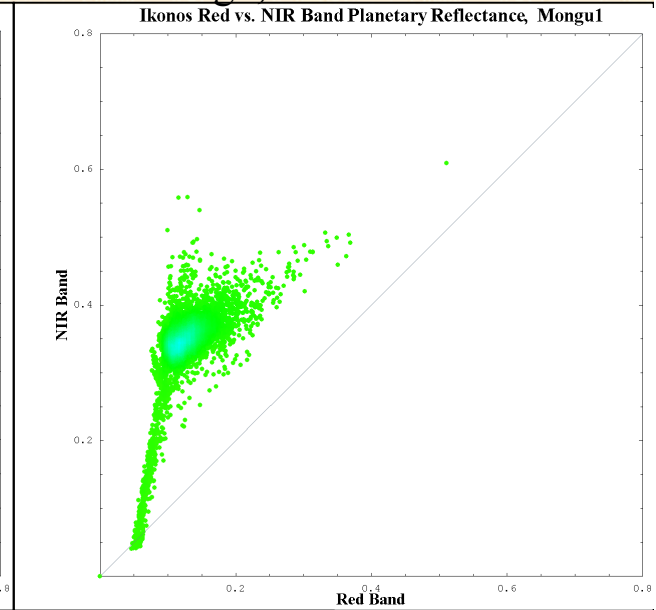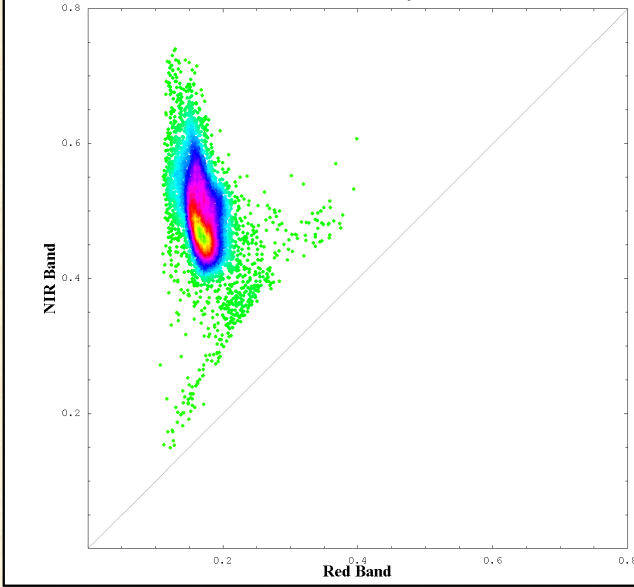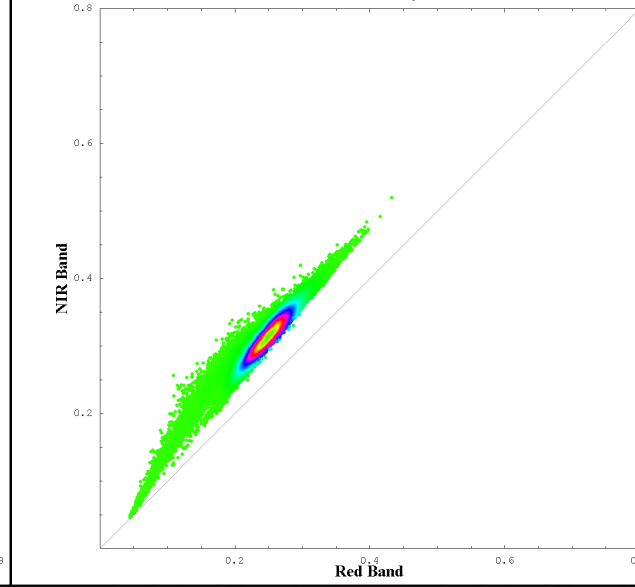
Phoenix MTFC Off 10/12/99

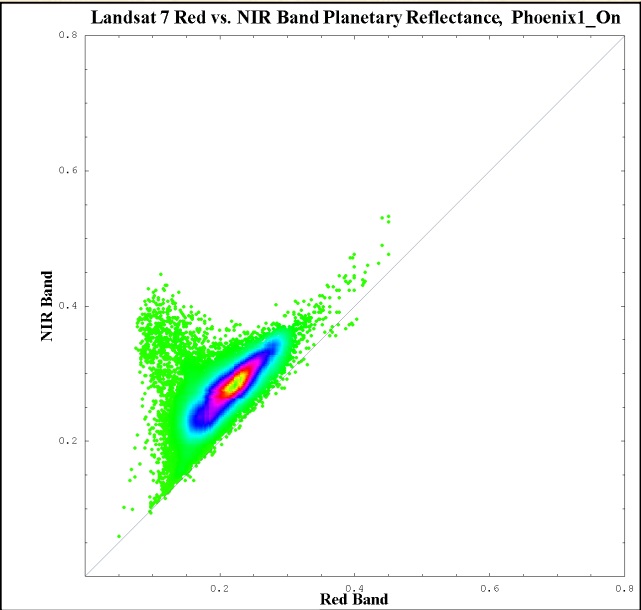Mongu, Zambia 4/10/00

Konza Prairie, KS 7/28/00
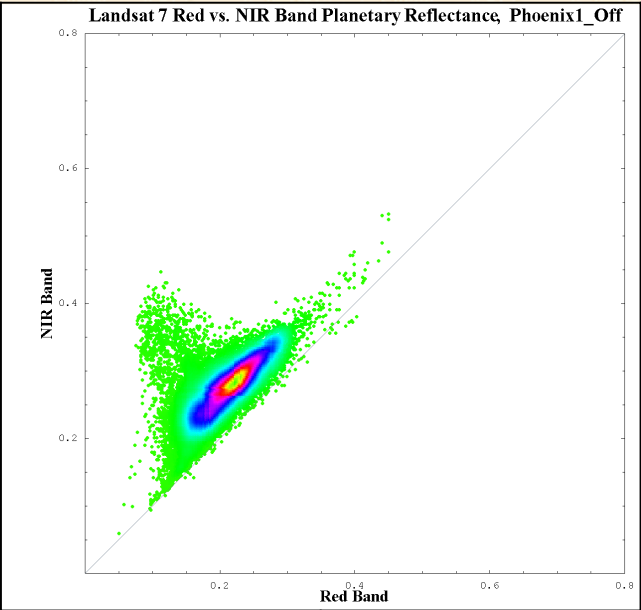
Sevilleta, NM 10/2/00

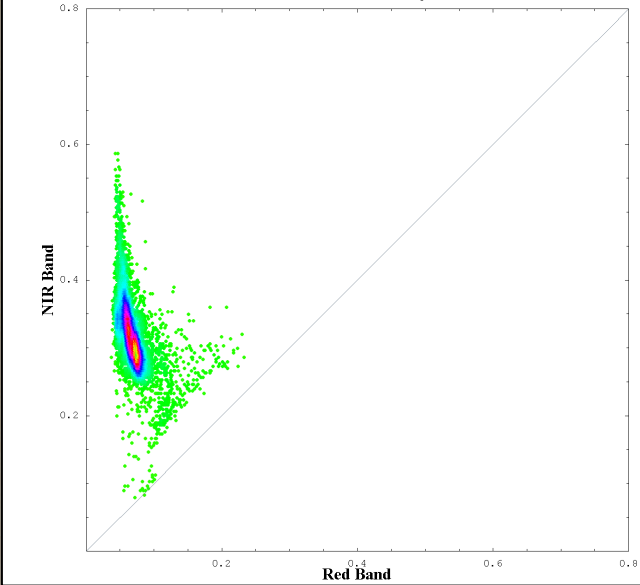# Comparison of Ikonos and Landsat 7: TM NIR vs Red Bands

Phoenix MTFC On 10/12/99   Phoenix MTFC Off 10/12/99   Mongu, Zambia 4/10/00
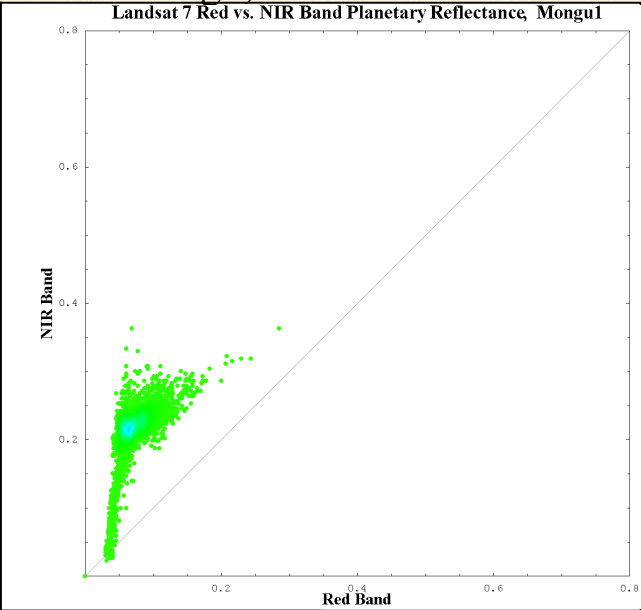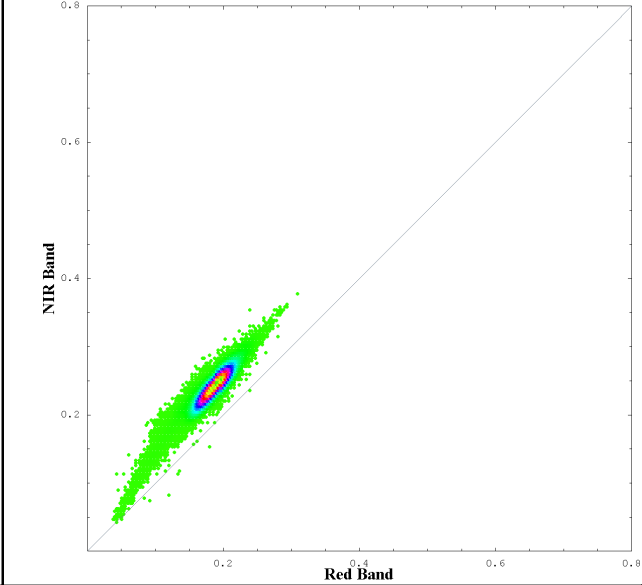
Konza Prairie, KS 7/28/00   Sevilleta, NM 10/2/00

Comparison of Ikonos and Landsat 7: Evidence of Sensor Limitations

NDVI image output for Sevilleta, Ikonos & TM
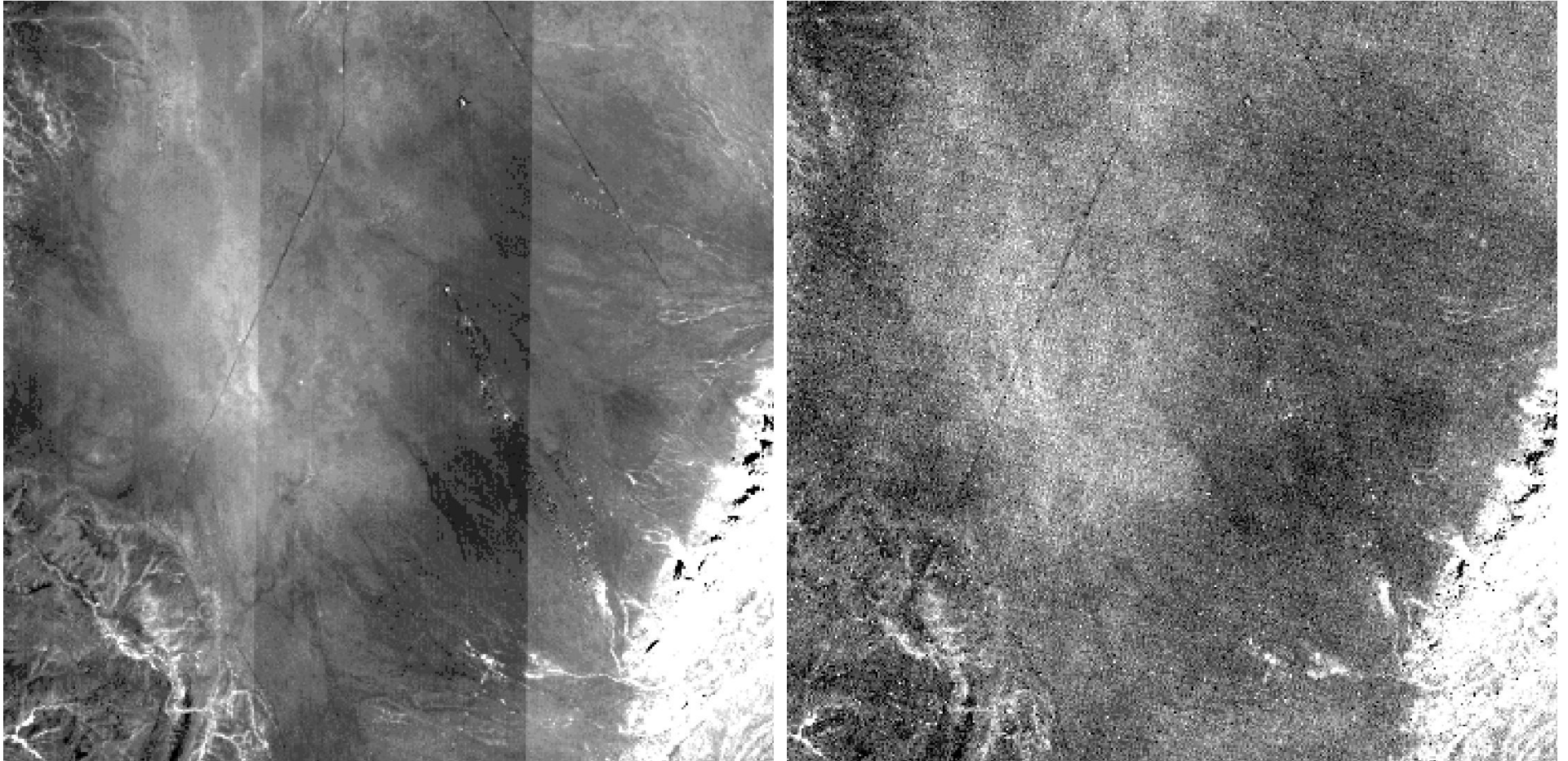
Certain landscape features are only visible at high resolution.

What are the dots/stars in this apparent image from space?

Kangaroo Rat holes are visible at 4m, but not at 30m

Conclusions (to date):

▪ **Quality of imaging meets or exceeds expectations.**

▪ **Supporting technical information (e.g. MTF, radiometric calibration) is not sufficient.**
** This demonstrates the value of cal/val activities in the Science Data Buy

▪ **Acquisition capacity of single 11km swath limits science applications.**

▪ **Important contribution to multi-scale assessment of Earth's terrestrial environment.**
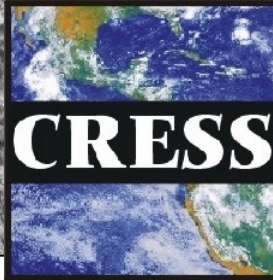
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